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Abstract

Introduction: Emotion regulation, the process of changing one's emotion or one's response to emotion, is necessary for efficiency when performing cognitive tasks, and is often measured using a Stroop-like task that provides conflict between emotional and factual information. Researchers have found that listening to music increases performance on cognitive tasks. For the present research it was hypothesized that listening to music samples that evoke different arousal and valence levels would affect participants' emotion regulation skills. *Method:* While completing an emotional-Stroop task, 38 Georgia State University undergraduates listened to three-minute excerpts of film scores known to evoke a particular mood and arousal state. *Results:* A repeated measures ANOVA revealed a significant difference between the types of music and an interaction between music type and word context. *Discussion:* These results provide evidence that different types of music may place different demands on attention, differentially disrupting Stroop performance, at least for the color-naming of nonacademic words. However, the absence of valence effects in these results suggest that the findings likely reflect arousal rather than mood induction.

Introduction

Emotion Regulation

Emotions occur in response to events, and make people more likely to respond to these events with particular behaviors (Gross, 2002). For example, children learn to respond to frightening things with fear, resulting in behaviors like hiding and fleeing. Emotions also influence the cognitive processes that underlie behavior, as when fear biases attention and alters memory, making individuals more likely to notice and to remember frightening stimuli (e.g., Chapman, Johannes, Poppenk, Moscovitch & Anderson, 2013; Fani et al., 2012). Though they influence cognition and behavior, initial emotional responses can also be moderated by cognition, a process called emotion regulation (Gross, 2002). That is, individuals can use cognition to modify the experience of emotion or the response to it. Researchers have studied the cognitive control of emotion to examine the efficacy of different regulation strategies, such as reappraisal or suppression (Ehring, Tuschen-Caffier, Schnulle, Fischer, & Gross, 2010; Goldin, McRae, Ramel, & Gross, 2008; Gross & John, 2003). These differing strategies occur in separate temporal points in emotion response and activate separate neural mechanisms (Goldin et al., 2008). Emotion regulation can improve efficiency when performing many cognitive tasks, such as decision-making, problem solving, and conflict resolution. For example, Heilman, Crisan, Houser, Miclea and Miu (2010) found that cognitive reappraisal of fear and disgust (i.e., convincing oneself that a situation is not really scary) allowed participants to be less risk averse in decision-making performance.

Emotional-Stroop

The Stroop task involves asking participants to name the color in which a word is printed and to ignore the semantic meaning of the word, which is hard to do if the words are themselves conflicting color words (Stroop, 1935). For example, it takes longer and produces more errors when the word RED is printed in blue than when the word ROD is printed in blue, even though “blue” is the appropriate response on both trials. This robust finding of interference from incongruous stimulus cues has generated two theories of explanation (e.g., MacLeod, 1991, 1992; Mama, Ben-Haim, & Algom, 2013). One view is that because reading is a highly practiced, automatic process, then the word-meaning information is processed faster than the controlled task of naming text colors. However, other data (e.g., Washburn, 1994) support a rival theory to this speed-of-processing account, one in which the strength of association between the stimulus cues (word color, word meaning) produces response competition. Attention resources, time, and effort are required to resolve this conflict, resulting in the classic Stroop interference effects—not just for color naming, but also for a large number of variations on Stroop-like tasks. To date there have been more than 4,000 publications on Stroop-like effects.

Given the relation described above between emotion, cognition, and behavior, it is unsurprising that many researchers have used a modified emotional-Stroop task to study participants’ efficiency of conflict resolution where affective stimuli are involved (e.g., Ben-David, Chajut, & Algom, 2012; Frings & Wuhr, 2012; Macleod, 1991). Such studies typically show that participants are slower and less accurate in naming the color of a negative word (e.g., DEAD) than a neutral word (e.g., BEAD). The magnitude of these Stroop-like interference effects has been shown to vary as a function of many variables of interest, including emotion regulation (Buhle, Wagner & Smith, 2010), aging (Dunajska, Szymanik, & Trempala, 2012), personality (Mauer & Borkenau, 2007; Paelecke, Paelecke-Habermann, & Borkenau, 2012), and a wide range of clinical and forensic variables (e.g., Dresler et al., 2012; Lagapoulos & Malhi, 2007; Mitterschiffthaler, et al., 2008; Price, Beech, Mitchell, & Humphreys, 2012; Wingenfeld et al., 2009). Most directly relevant to the present investigation, the magnitude of the emotional-Stroop effect has also been found to vary as a result of mood induction (e.g., Ben-Haim, Mama, Icht, & Algom, 2014; Gilboa-Schechtman, Revelle, & Gotlib, 2000; Nixon, Liddle, Nixon, & Liotti, 2013). For example, Schuch and Koch (2014) used film clips to induce positive or negative mood, and reported significant moderation of Stroop-like effects for the negative-mood manipulation.

Music

Researchers have shown that listening to music influences mood and arousal (Garrido & Schubert, 2011; Lingham & Theorell, 2009; Pannese, 2012; Schafer & Sedlmeier, 2011). Research has also linked music listening to psychological functioning (Thoma, Scholz, Ehlert, & Nater, 2012). Thoma, Ryf, Mohiyeddini, Ehlert, and Nater (2012) examined the likelihood that participants would prefer to listen to music that evoked specific mood and arousal states to regulate their emotions in everyday situations. Lesuik (2010) found that listening to preferred music significantly improved performance on high cognitive demand tasks, suggesting that music increases efficiency for cognitive tasks. Graham, Robinson, and Mulhall (2009) found an effect of music on reactions of an emotional-Stroop task, but they used a composition specifically designed not to evoke any emotions or arousal states. Therefore, research supports the idea that listening to music can influence emotion regulation abilities, but no researcher has examined whether the specific musical type effects the emotional regulation with an emotional-Stroop task. Given the relationships between emotion regulation, conflict resolution, and music, one could hypothesize that listening to different mood- and arousal-provoking music will differentially influence participants' concurrent performance on a Stroop task requiring emotion regulation to resolve conflicts. The present study was designed to test this hypothesis.

Method

Participants

Participants were 38 (30 females, 8 males; M=21.16 years, SD= 7.39, 18-49 years of age) Georgia State University undergraduates, who received course credit for their participation. All but six of the participants reported being right-handed. The participants self-identified as identifying with the following racial/ethnic categories: African American (n=15), Caucasian (n=7), Asian (n=7), Multiracial (n=5), Pacific Islander (n=1), and Other/Unidentified (n=3). All of the participants provided written informed consent before inclusion in the experiment.

Materials

The participants used Dell Optiplex 755 computers with Visual Basic software to view the stimuli. The sounds on the computer were played at maximum volume, but the participants were permitted to decrease the sound level to a comfortable level if necessary. The stereo headphones provided had a frequency response of 20-20,000Hz and a sensitivity of 90dB/mW, well beyond the range of the music sequences.

Procedure

After providing informed consent and optional demographic information, participants read instructions and then completed a training period to familiarize themselves with the task. The training trials consisted of a string of letters (XXXX) in the middle of the screen. The letters were all blue, green, red, or yellow. According to the instructions, participants pressed the left-arrow key on the keyboard if the letters were blue or green, but pressed the right-arrow key if the letters were red or yellow. Participants were instructed to respond as quickly and accurately as possible.

Once the participant had responded correctly to eight consecutive training trials, test trials immediately began and music automatically began to play through the headphones. The test trials included presentations of words encountered in different contexts (Academic or Daily), which were thought to evoke a particular mood (Positive, Neutral, or Negative) and which were printed in different colors (Blue, Green, Red, Yellow). The words are listed in Table 1. Irrespective of the word (or XXXX string) presented, the participant was required to indicate the color of the letters using keyboard keys, as described above. The participant pressed the left- or right-arrow keys to categorize the color into one of two groups (Blue/Green vs. Red/Yellow) immediately after perceiving the stimulus.

While categorizing the stimuli according to color, the participants listened to continuous segments of music known to evoke different mood and arousal levels (Eerola & Vuoskoski, 2010). The music pieces were film scores, so they had no verbal components. Each was approximately 3 minutes in length. Four types of music were used, each described in two dimensions (valence and arousal): Tender (positive mood, low arousal), Sad (negative mood, low arousal), Happy (positive mood, high arousal), and Fear (negative mood, high arousal). Four music samples in each category or type were presented. The order of these music segments was counterbalanced across participants. Thus, participants indicated the color of various positive, neutral, or negative words while listening to segments of tender, sad, happy, and fearful music in pseudorandom order. Participants completed emotional-Stroop color-naming trials continuously, but at their own pace, for 14 minutes, which was the duration of the four blocks of music when combined. After the participants finished the experiment, participants received a copy of their signed consent and a debriefing form explaining more about the experiment.

	Academic Words	**Daily Words**
Positive	Pass, Honors, Graduate, Holiday, Weekend	Happy, Smile, Joyful, Play, Fun
Neutral	Professor, Book, Pencil, Students, Pen	Day, Road, Biscuit, Computer, Deer
Negative	Exam, Quizzes, Fail, Essay, Homework	Sad, Disgust, Sickness, Cry, Sorrow

Table 1: *This is the list of words used in the experiment. The mood evoked has three levels: positive, neutral, and negative. The word context has two levels of academic and daily.*

Results

All post-training trials were scored for accuracy and, for trials in which word color was identified correctly, for response time. All responses longer than four seconds or more than 3 standard deviations above the mean (outliers) were excluded. Means were computed by condition, word type, and by music mood. Repeated-measures analysis of variance (ANOVA) was used to determine whether the speed of color-naming differed as a function of music type (Fear, Happy, Sad, and Tender), word context (Academic and Daily), and word emotion (Positive, Neutral, and Negative). The ANOVA revealed a significant difference between the types of music, $F(3,29)= 3.02$, $p=.043$, $\eta^2 =.089$. Bonferroni's post hoc test revealed that mean response time was significantly faster while listening to the Happy music sample ($M=0.883$ s, $SD=.053$) than when listening to the Tender music sample, ($M=0.795$ s, $SD= .045$, $p=.025$). The difference in response times between the Fear music sample ($M=0.865$ s, $SD=.05$) and the Tender music sample was not statistically significant ($p=.059$). There was no difference in the response times for the Sad music sample ($M=0.836$ s, SD=0.044) relative to the other music samples. A significant interaction between music type and word context was also observed, $F(3,29)= 3.639$, $p=.027$, $\eta^2 =.105$. The Greenhouse-Geisser method was used to correct for multiple comparisons. The marginal means of the interaction between music type and word context are displayed in Figure 1. There were no reliable differences between the music types for naming the color of Academic words, but responses were significantly longer when naming the color of Daily words while listening to fear and happy music than while listening to sad and tender music, with no additional comparisons significant. No significant differences or interactions were observed as a result of word valence (mean response times = 0.857, 0.824, and 0.854 s for negative, neutral, and positive words respectively).

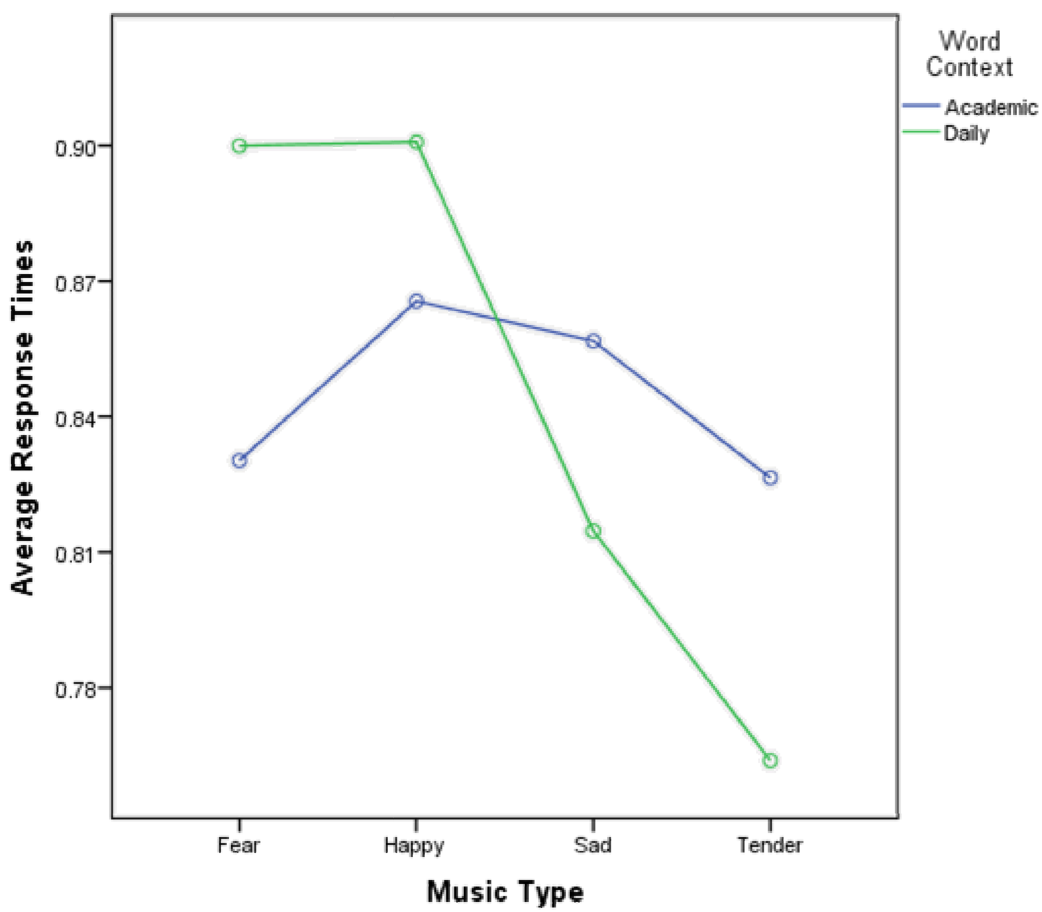

Figure 1: *This graph shows the marginal means of response times for all participants during each musical condition. The context of the words is represented in different colors, with Academic in blue and Daily in green.*

Discussion

Researchers have demonstrated that listening to music generally enhances emotional regulation abilities (Graham, Robinson, & Mulhall, 2009), but the present study is the first to show that listening to different music types influences participant performance on such tasks. The time required to name the color of a word was found to differ significantly as a function of music type, such that participants' reaction times while listening to Happy music were significantly faster than when listening to Tender music. The Music Type X Word Context interaction shows that this effect was not apparent for the academic words (e.g., BOOK, HOLIDAY, HOMEWORK), but rather reflects an effect of music on color-naming for words like SMILE, ROAD, and SORROW. However, the valence of the words (negative, neutral, or positive) did not influence response times. Similarly, it does not appear that the valence of the music influenced these Stroop-like effects significantly. Participants in the Eerola and Vuoskoski (2010) study rated Happy music samples with high arousal and positive valence, but the Tender samples were also rated as positive valence, albeit with low arousal. Participants were also faster to respond while listening to Tender music than when listening to Fear music. Participants in Eerola and Vuoskoski's (2010) study rated the Fear music samples as high arousal and negative valence. Thus, it appears that the two types of arousing music (Happy, Fear) generally resulted in longer latencies for naming the color of nonacademic words, compared to the two low-arousal music types (Sad, Tender). Listening to highly arousing music appears to impair performance on tasks requiring emotion regulation and compromises color-naming speed.

Of course, the finding that arousal influences performance is not new. Indeed, it is one of the few behavioral relations that have risen to the status of a psychological law (i.e., the so-called "Yerkes-Dodson law"; Yerkes & Dodson, 1908). However, this predictable inverted U-shaped function that describes the relation between performance and arousal provides little insight to the present results, because Stroop performance was worse during the high-arousal music compared to the low-arousal music. Although Yerkes and Dodson (and many subsequent researchers) did find that very high levels of arousal impede performance, it seems unlikely that the music selections used here produced such debilitating arousal; rather, it seems that, compared to the Sad and Tender selections, the Happy and Fear music attracted attention resources, and challenged participants' capacity for emotion regulation. Because music type did not interact significantly with word valence, it does not appear that the mechanism for this increased interference was mood activation or potentiation of happy-related and fear-related word meanings to compete with word color for selection. Instead, participants may have simply found it more difficult to remain focused on the Stroop task while the high-arousal selections played.

However, this competition for attention between the Stroop task and high-arousal music was only found when the Stroop task involved presentation of Daily (i.e., nonacademic) words. There seems to be no published study in which emotion regulation and word context, (i.e., whether the words pertained to academic versus daily life more generally) are both examined. Although the effect of music type on response times discussed above did not vary as a function of word valence, it did interact with the word context variable. Further analysis indicates that participants were faster at processing the color of Academic-context words while listening to Fear and Happy music samples; however, when listening to Sad and Tender music samples, participants were faster at processing the color of Daily-context words. This interaction could be due to the arousal levels associated with academic and daily situations: participants are accustomed to dealing with higher levels of arousal related to academic tasks, and respond faster to words from academic context when listening to music samples that increase arousal. So it is possible that Happy and Fear music made it harder to ignore the meaning of words like “happy,” “smile,” and “cry”—but also neutral words like “road,” “biscuit,” and “deer” (because there was no interaction with word valence)—or that Sad and Tender music made it easier to ignore these same meanings and to focus on the color of the print. Explicating this effect will require additional investigation.

Contrary to Ashley, Honzel, Larsen, Justus, and Swick (2013), there was no significant difference between reaction times as a function of word valence in the current study. That is, there was no emotional-Stroop effect, or slower and/or less accurate color-naming responses for negative-valence words than for neutral and positive words. Responses times for negative words were longer, albeit not reliably, than neutral words; however, positive-word response times were also longer than neutral and almost identical to negative. In any case, the differences were not statistically significant. A possible reason for this is that recognizing word valence was irrelevant to the task, which has been demonstrated to lessen the Stroop interference (Fring & Wuhr, 2012). However, if this were the case, we would expect to find no effect of word context either. Researchers have shown that listening to music lessens the effect of threatening words on the Stroop (Graham, Robinson, & Mulhall, 2009), so act of listening music could have reduced the differences to a negligible level, essentially making all the words neutral. Follow-up investigations should have participants rate the valence of the words while the various types of music is playing so as to test whether any mood induction produced by the tunes and any effect of emotion regulation required by those moods is offset by this threat-reducing effect of listening to music.

After many decades of studying the effect of arousal on attention, including with many Stroop-task experiments, the relation remains poorly understood. Our findings show that music valence and arousal affect attention, perhaps by taxing emotion regulation skills. Clarifying these effects and determining why no evidence of word-valence based emotional-Stroop effects was found will help to resolve the role of music in the competition for attention. This in turn could produce implications that are helpful for treating a wide range of attention- and executive-function failures, for example allowing music therapists to implement interventions for depression, post-traumatic stress disorder, and related conditions. It is important to separate the general effect of music listening from the specific effects that certain genres could generate. The results of the present study (and follow-up investigations) could influence the generation of emotional-regulation strategies and training methods. The finding that word context changes the music effect is of particular interest to students, who could listen to specific music when studying.

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